



Regional Carbon Capture, Transport, and Storage Opportunities in Louisiana

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Dane McFarlane
Director of Research
Great Plains Institute



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Better Energy.
Better World.

Regional CO₂ Transport Infrastructure Study

Study Components

1. Identify near-term opportunities for CO₂ capture retrofit
2. Locate areas of CO₂ storage and use
3. Model optimized CO₂ transport infrastructure to maximize capture and storage

Primary Partners:

REGIONAL
CARBON
CAPTURE
DEPLOYMENT
INITIATIVE



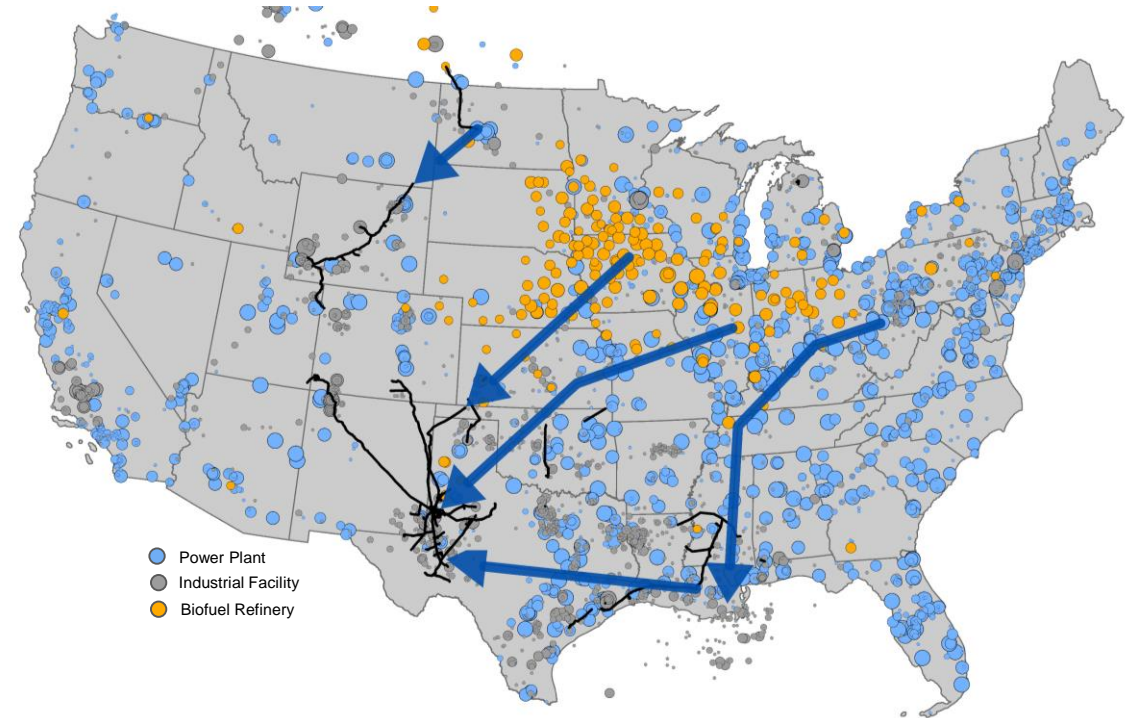
INDIANA UNIVERSITY



Stanford
University



Initial CO₂ Corridor Scoping



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Analytical Report

Published in 2020

Economic Impact & Jobs Study

Rhodium Group 2020-21



Transport Infrastructure for Carbon Capture and Storage

WHITEPAPER ON REGIONAL INFRASTRUCTURE FOR MIDCENTURY DECARBONIZATION

Authored by

Elizabeth Abramson and Dane McFarlane
Great Plains Institute

Jeff Brown
University of Wyoming

JUNE 2020



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REGIONAL CARBON CAPTURE DEPLOYMENT INITIATIVE

Louisiana IMPLEMENTING CARBON CAPTURE AND STORAGE TECHNOLOGY

KEY TAKEAWAYS

- There are 61 facilities that qualify for the 45Q tax credit in Louisiana, which accounts for 75% of all emissions from facilities in the state. Of these 61 facilities, 32 have been identified as likely economically feasible candidates with the estimated potential to capture over 23 million metric tons of CO₂ a year.
- As of 2017, Louisiana has the fourth highest CO₂ emissions in the nation with roughly 60 percent of emissions coming from the industrial sector and 14 percent from electricity generation.
- The Louisiana Geologic Sequestration of Carbon Dioxide Act is the cornerstone legislation within the state for future deployment of carbon capture utilization and storage.
- In addition to having favorable geography for saline storage, Louisiana is also in close proximity to the Permian Basin, which provides an additional storage option by selling captured CO₂ for EOR.

The Regional Carbon Capture Deployment Initiative brings together state officials with diverse industry, NGO, labor, and other stakeholders to promote broad scale deployment of infrastructure for carbon capture, CO₂ pipelines, enhanced oil recovery (EOR), other forms of geologic storage, and beneficial utilization of CO₂ in the Western and Midwest regions of the country.

The initiative is staffed by the Great Plains Institute (GPI), a nonpartisan, nonprofit working to transform the energy system to benefit the economy and environment. For more information on this effort, go to carboncaptureready.org or contact Patrice Lahlum at plahlum@gpiid.net.

SOURCES BY INDUSTRY & VOLUME

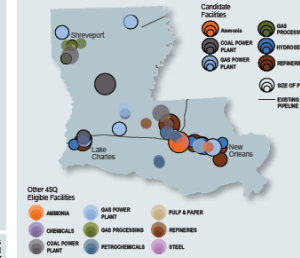
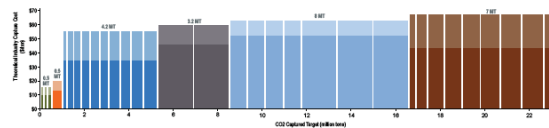


Figure 1: Louisiana has many facilities large enough to qualify for the 45Q carbon capture tax credit, including coal and gas power plants, gas processing facilities, and petroleum refineries. Facilities identified by the Regional Carbon Capture Deployment Initiative as potential early candidates for capture retrofits, based on emissions, equipment, and estimated capture cost, are shown with outlines and darker colors. Details on these facilities are listed below.
Source: Great Plains Institute 2019; EPA 2016.

POTENTIAL CANDIDATE FACILITIES FOR CAPTURE WITH ANNUAL EMISSIONS



*Faded areas of each bar represent estimated range of capture costs, with the darker color representing minimum expected cost.
Figure 2: The Regional Carbon Capture Deployment Initiative estimated theoretical facility capture costs based on published capture equipment costs, facility-specific operational patterns, existing equipment, and level of emissions. Most states have a large number of facilities eligible for 45Q. Of those facilities, the above graph depicts likely economically feasible candidates based on estimated capture cost. The facilities represented in this graph are not meant to be definitive. Commercial decisions by participating companies, and policy and regulatory decisions by state governments, will ultimately determine if a project is feasible for carbon capture. CO₂ captured Target refers to the amount of carbon dioxide that can be expected to be captured at a facility considering relevant technological and economic constraints.
Source: GPI 2016; EPA 2016.

Maps and graphics within this document are based on work by the Great Plains Institute (GPI) to help the Regional Carbon Capture Deployment Initiative identify facilities that qualify for the federal 45Q tax credit and are optimal near-term investment opportunities for carbon capture for each state. For more information, visit carboncaptureready.org.

REGIONAL CARBON CAPTURE DEPLOYMENT INITIATIVE

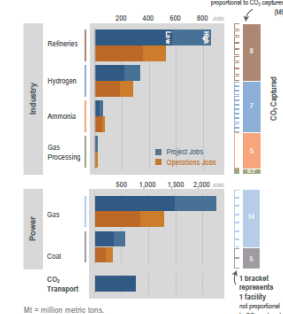
JOBS AND ECONOMIC IMPACT OF CARBON CAPTURE DEPLOYMENT Louisiana

| TOTAL JOBS POTENTIAL | | |
|----------------------|-----------------|---------------------|
| Project Jobs | Operations Jobs | Infrastructure Jobs |
| 4,060 | 2,500 | 780 |

Louisiana has the opportunity to create an annual average of up to 4,840 project jobs over a 15-year period and 2,500 ongoing operations jobs through the deployment of carbon capture at 33 industrial and power facilities. The retrofit of equipment at these facilities would capture nearly 40 million metric tons of carbon dioxide (CO₂) per year. Along with the development of CO₂ transport infrastructure, this would generate up to \$15.6 billion in private investment.

CREATING JOBS & CAPTURING CARBON
Carbon capture is essential to meeting mid-century emissions reduction goals while retaining and growing a domestic base of high-wage energy, industrial, and manufacturing jobs. Carbon capture retrofits require facilities to be outfitted with capture technologies such as amine scrubbers to remove CO₂ from exhaust gas and compressors to make the CO₂ transport-ready, that are dependent upon the type of industrial plant and vary across industries and facilities. There are jobs associated with the equipment, materials (e.g. cement and steel), engineering, and labor required to install the capture technology, as well as ongoing jobs to operate and maintain the retrofits. These are referred to as project jobs and operations jobs.

ANNUAL PROJECT AND OPERATIONS JOBS



MT = million metric tons.

Rhodium Group performed an economic analysis based on the Regional Carbon Capture Deployment Initiative's near- and medium-term capture potential scenarios.¹ The Rhodium analysis quantifies the economic impact and employment opportunities of carbon capture retrofits by deploying state-specific data in the IMPLAN economic model. The analytical results measure the impact of project investment and operation costs through expected annual jobs. Average annual project jobs were calculated assuming deployment of all projects within the 15-year period from 2021-2035. The jobs reported are in-state jobs, directly associated with carbon capture retrofits. They do not include other jobs at the facilities, nor indirect and induced jobs.

RESULTS

Three of the state's gas processing facilities, 11 hydrogen facilities, and nine refineries have the combined potential to create an annual average of up to 1,260 project jobs and 880 ongoing operations jobs and capture 21 million metric tons of CO₂ per year. In the power sector, two of the state's coal plants and seven gas plants have the combined potential to create an annual average of 2,800 project jobs and 1,610 ongoing operations jobs and capture 19 million metric tons of CO₂ annually. Additionally, the construction of CO₂ transport infrastructure would create an annual average of 780 project jobs.

This figure (left) depicts the low and high range of estimated annual average project jobs, transport infrastructure jobs, and ongoing operations jobs that could be created through carbon capture retrofits at industrial and power facilities in Louisiana. The potential amount of CO₂ captured and the number of potential near- or medium-term capture facilities in each industry are shown on the right.

CARBON CAPTURE JOBS AND ECONOMIC IMPACT SUMMARY

| Industry | Number of Facilities | Total Capture Target Metric Tons | Private Investment Million Dollars | Annual Average Project Jobs 2021-2035 | Annual Operations Jobs |
|--|----------------------|----------------------------------|------------------------------------|---------------------------------------|------------------------|
| Ammonia | 1 | 5,000,000 | \$150 - \$220 | 40 - 60 | 60 - 70 |
| Coal Power | 2 | 5,000,000 | \$1,200 - \$1,800 | 370 - 560 | 220 - 330 |
| Gas Power | 7 | 14,000,000 | \$4,700 - \$7,400 | 1,490 - 2,240 | 850 - 1,280 |
| Gas Processing | 3 | 700,000 | \$40 - \$60 | 15 - 20 | 14 - 20 |
| Hydrogen | 11 | 7,000,000 | \$700 - \$1,060 | 220 - 330 | 190 - 260 |
| Refineries | 9 | 8,000,000 | \$1,200 - \$1,940 | 570 - 850 | 360 - 520 |
| CO ₂ Transport Infrastructure | - | - | \$1,300,000,000 | 780 | - |

¹ Rhodium Group analytical results: rhg.com/research/

For more information, visit carboncaptureready.org

- 36,000 – 54,200 average jobs per year over 15 years
- 7,000+ jobs in Louisiana

Download paper and state fact sheets at:
carboncaptureready.org/analysis



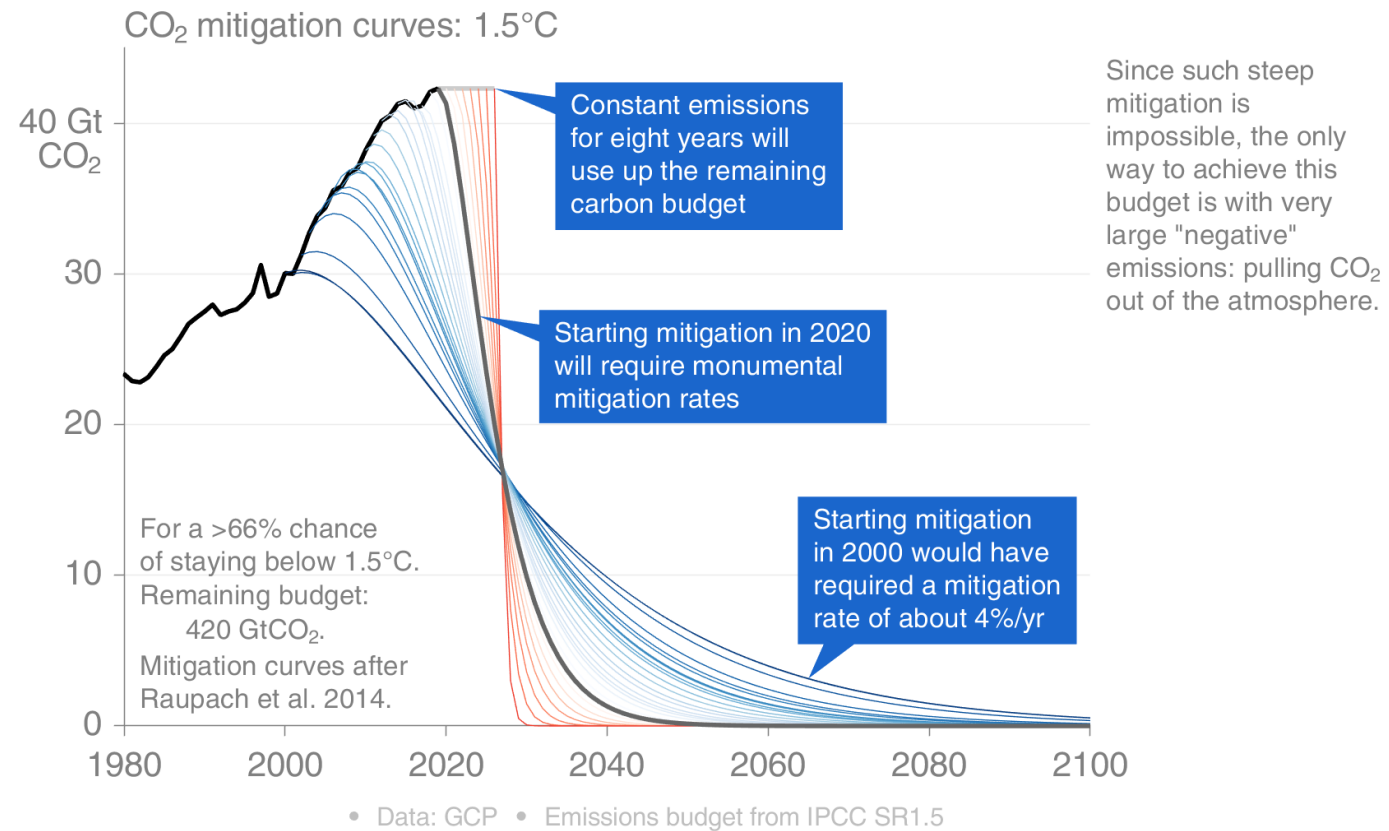
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UN IPCC: 1.5°C Scenario Carbon Budget

Time is running out for moderately achievable reductions

Delayed action past 2020s will require extreme reductions that can only be achievable through “negative” emissions.

Global Carbon Budget for 1.5°C Temperature Change



Since such steep mitigation is impossible, the only way to achieve this budget is with very large “negative” emissions: pulling CO₂ out of the atmosphere.

Figure by Robbie Andrew
<https://folk.universitetetioslo.no/roberan/RobbieAndrew.shtml>



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UN IPCC 2019: Steepest reductions in fossil fuel and industry must occur before 2040

Global target: Net-Zero 2050

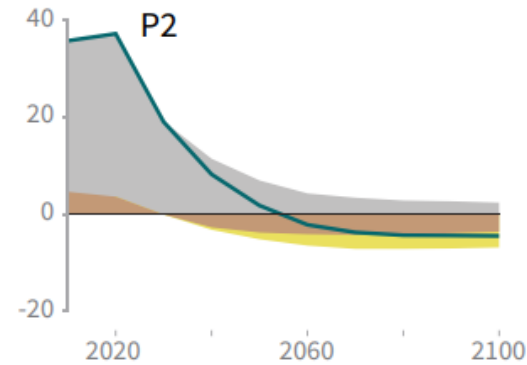
IPCC:
Global GHG reduction of 45% needed by 2030 (more if we don't act now) for 1.5°C to 2°C.

Reductions must begin in the 2020s and achieve **fastest pace in the 2030s**.

Delayed action increases need for negative emissions from capture and storage.

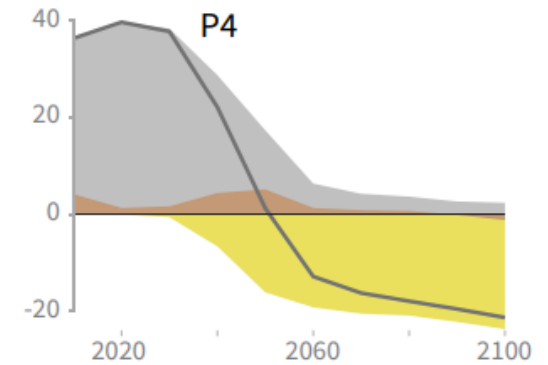
Steep, early reductions.

Carbon storage through ag and forestry, bioenergy, and carbon capture.



Delayed, slow reductions.

Extreme levels of carbon capture, negative emissions, and bioenergy



● Fossil fuel and industry ● AFOLU ● Negative emissions

AFOLU: Agriculture, farming, and other land use

Source: IPCC 2019



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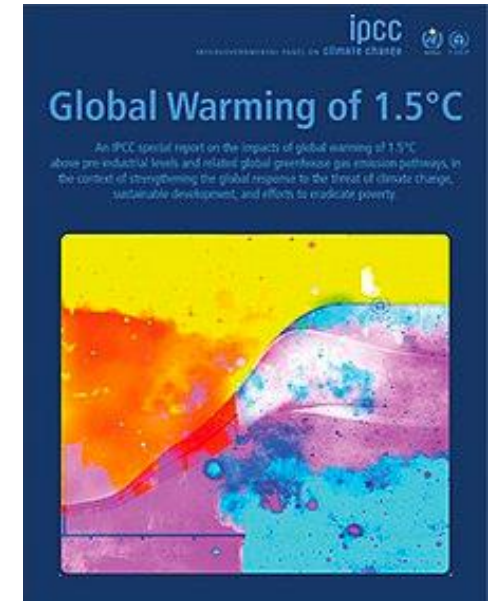
Carbon Capture is essential to meeting mid-century decarbonization goals — and doing so affordably

IPCC 5th Assessment:

Meeting 2° C goal costs 138% more without carbon capture.

IPCC 1.5 C modeling:

Atmospheric CO₂ removal through direct air capture and bioenergy with carbon capture is needed—in addition to **economywide industrial carbon capture.**



U.S. Industrial Sector Emissions

Industrial Process Emissions

- Process emissions result from the manufacture of products
- Not strictly related to energy use
- Often the result of chemical processes that release CO₂
- Hard to decarbonize without carbon capture or new techniques

Emissions

On-site combustion:

Process Emissions:

Indirect Emissions:

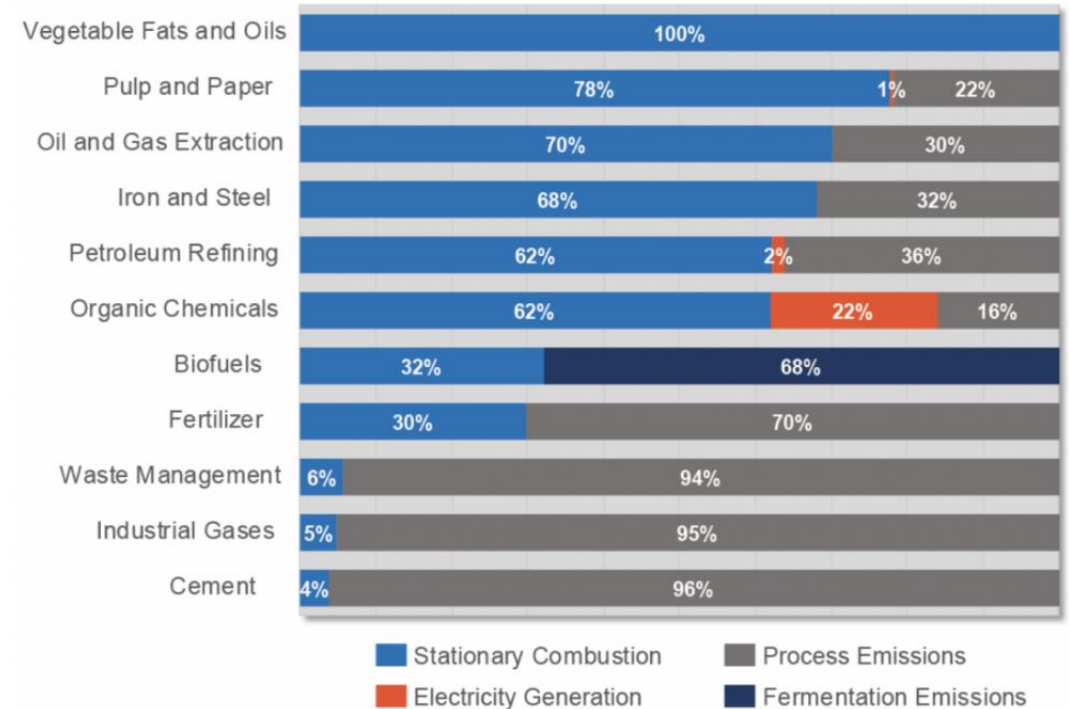
Reduction Strategy

Electrification & Fuel Switching

Carbon Capture; R&D and New Technology

Decarbonizing Electric Grid

Direct Emissions: U.S. Midcontinent Facilities



Figures authored by Elizabeth Abramson, Great Plains Institute, 2020
Source: EPA 2018



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CO₂ Capture Opportunities: Industrial and Power Facilities

Section 45Q Tax Credit for CO₂ Storage

Geologic Saline: \$50 / ton
EOR Storage: \$35 / ton

Minimum Capture Thresholds

Industrial Facility: 100 thousand tons CO₂
Power Plants: 500 thousand tons CO₂

Near- and Medium-Term Screening Criteria:

- 45Q Eligibility
- Operational patterns
- Expected life
- Right-size capture equipment to specific units within each facility

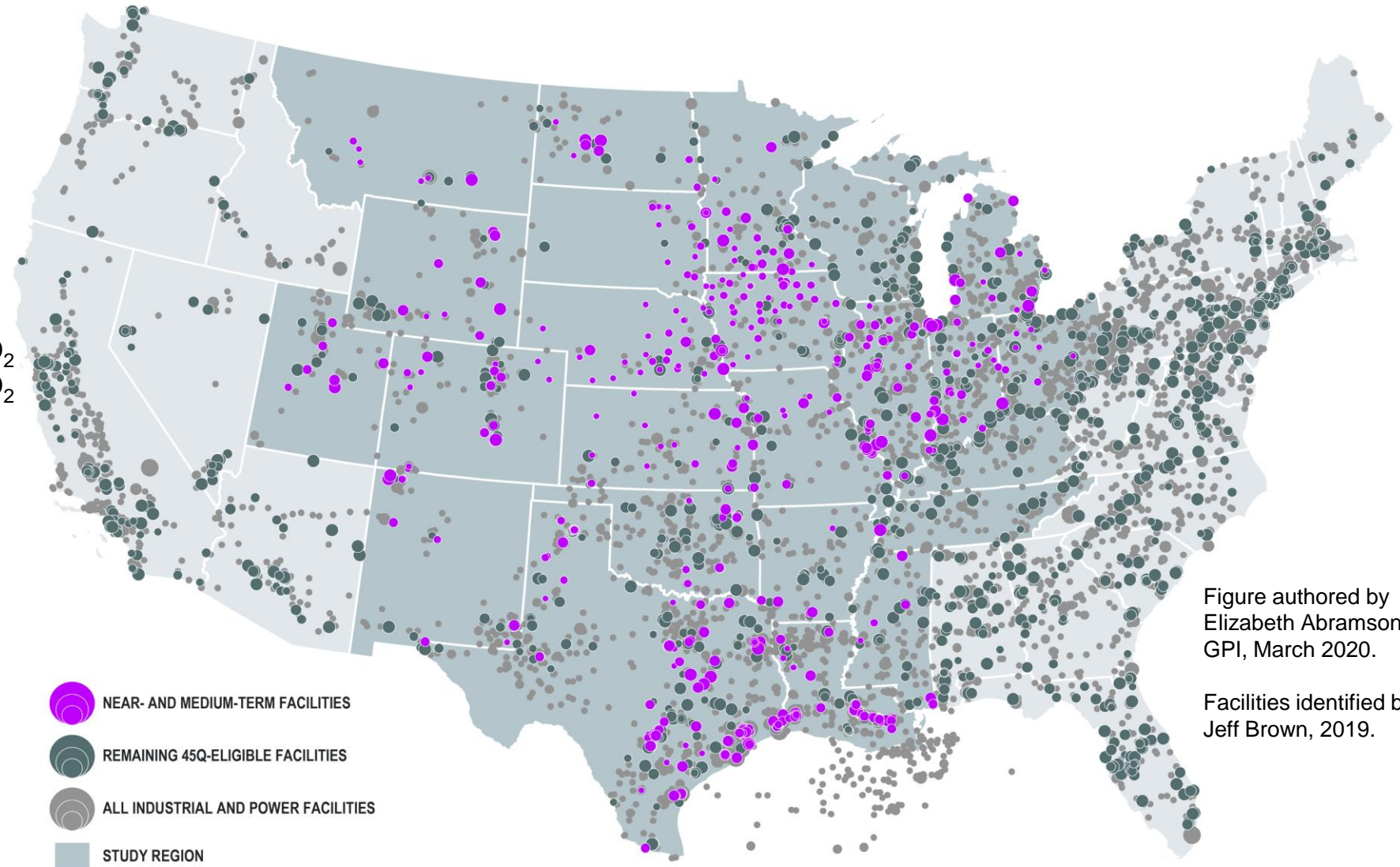


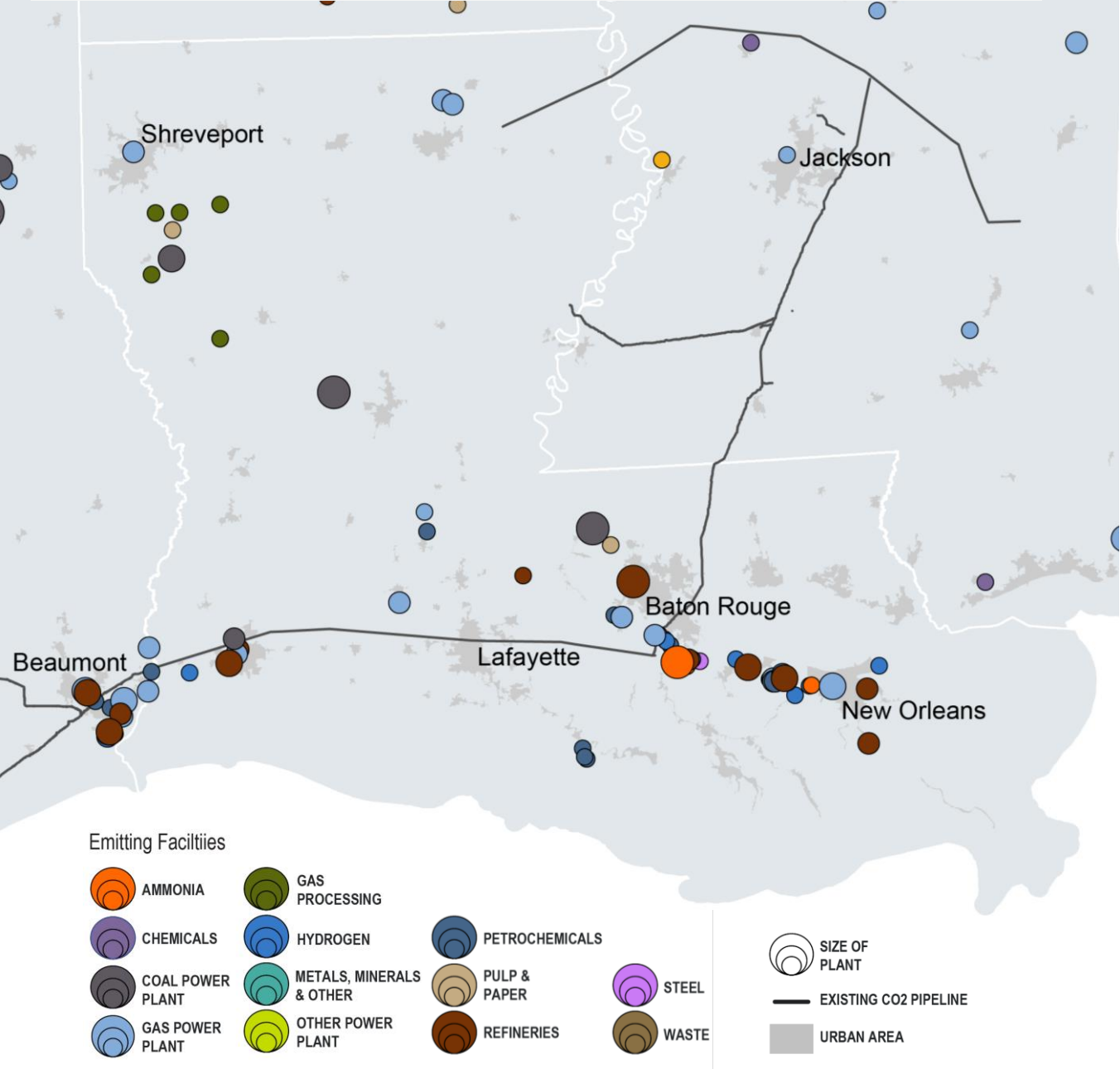
Figure authored by
Elizabeth Abramson,
GPI, March 2020.

Facilities identified by
Jeff Brown, 2019.



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45Q-Qualifying Power and Industrial Sources of CO2 in Louisiana



| Industry | # of 45Q Qualifying Facilities | 45Q Qualifying Emissions (million metric tons CO2) | Total # of Facilities in Louisiana | Total Facility Emissions in Louisiana (million metric tons CO2) |
|--------------------------|--------------------------------|--|------------------------------------|---|
| Ammonia | 4 | 8.9 | 4 | 8.9 |
| Chemicals | 1 | 0.3 | 31 | 3.8 |
| Coal Power Plant | 4 | 18.5 | 4 | 18.5 |
| Gas Power Plant | 12 | 23.2 | 26 | 26.0 |
| Gas Processing | 4 | 0.8 | 227 | 11.9 |
| Hydrogen | 10 | 7.4 | 13 | 7.6 |
| Metals, Minerals & Other | - | - | 25 | 2.4 |
| Other Power Plant | - | - | 1 | 2.1 |
| Petrochemicals | 12 | 10.2 | 20 | 14.2 |
| Pulp & Paper | 2 | 1.4 | 9 | 2.8 |
| Refineries | 11 | 30.7 | 15 | 32.1 |
| Steel | 1 | 0.1 | 1 | 0.1 |
| Waste | - | - | 25 | - |
| Grand Total | 61 | 101.4 MMT | 401 | 130.5 MMT |

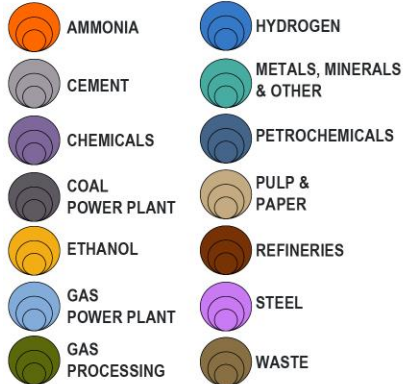
MMT: million metric tons CO2

Source: EPA GHGRP 2018

Near- and Medium-Term Opportunity: **23.3 million metric tons CO2**

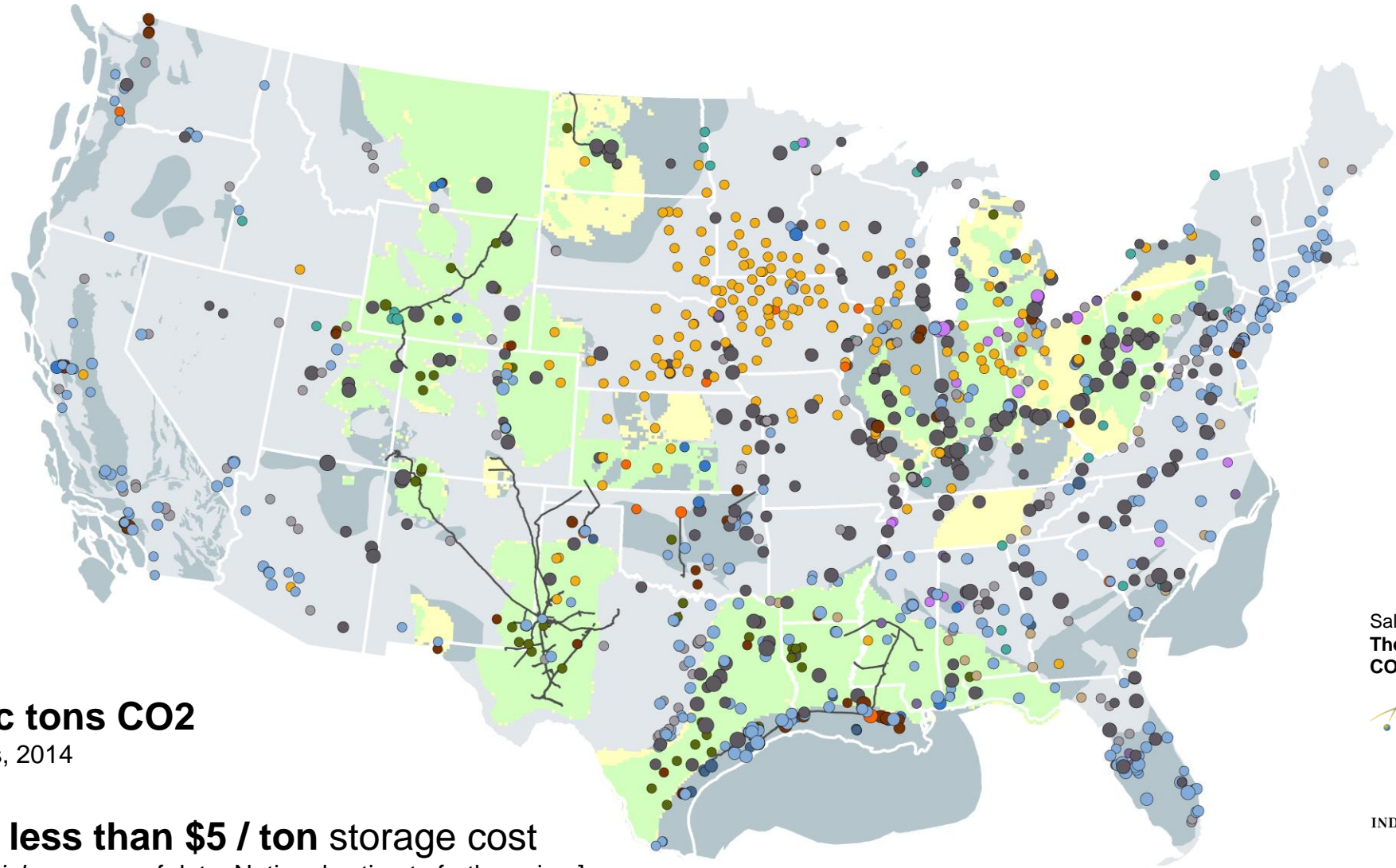
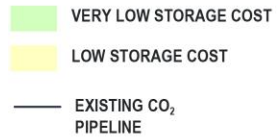
Geologic CO₂ Storage

45Q-ELIGIBLE INDUSTRIAL EMITTERS



SALINE FORMATION

CHARACTERIZED BY SCO₂T:



US Saline Storage Potential

8.3 to 21.6 trillion metric tons CO₂

U.S. DOE, U.S. Carbon Storage Atlas, 2014

1.8 trillion metric tons at less than \$5 / ton storage cost

[Conservative estimate based on *partial* coverage of data. National estimate forthcoming.]

Los Alamos National Lab and Indiana Geological Survey, SCO₂T Model, 2020

Saline data via
The Sequestration of
CO₂ Tool (SCO₂T)



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Figure authored by Elizabeth
Abramson, GPI, March 2020



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Louisiana Potential CO2 Demand for Enhanced Oil Recovery

Data from ARI (2018)

Potential Import of CO2 into Louisiana

Screened Near and Medium-Term Opportunities, not including later phase 45Q Qualifying Facilities

| Supply Region | To Target Region | Economically Feasible Capture |
|---------------|------------------|-------------------------------|
| Midwest | Gulf | 48 million tons |
| Louisiana | Louisiana | 23 million tons |

Source: GPI 2020

Geologic CO2 Storage Potential in Louisiana

Technical Potential

Annual: 2.3 billion metric tons

Total: 70.3 billion metric tons

Source: DOE NATCARB 2016; SCO2T 2020; GPI 2020.

Oil Fields

▲ Could purchase CO2 when oil is \$40 / bbl

▲ Could purchase CO2 when oil is \$60 / bbl

Saline Formations

Very Low Cost Storage

Low Cost Storage

Moderate to High Cost Storage

Not Yet Characterized

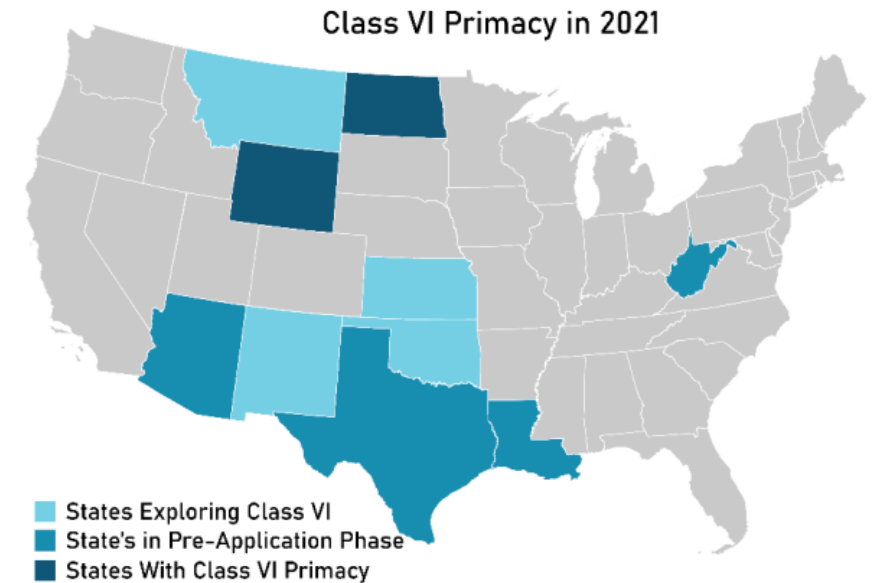
Class VI Primacy for Well Permitting

EPA's Class VI & the Underground Injection Control (UIC) Program

- Regulatory framework to ensure that large volumes of CO₂ captured from industrial facilities, power plants and ambient air can be safely and securely stored underground long-term.
- Requirements for well siting, permitting, operation, testing and monitoring, post-injection site care and site closure.
- Reporting under GHGRP Subpart RR is required for all facilities with a Class VI permit.

Federal and State Capacity

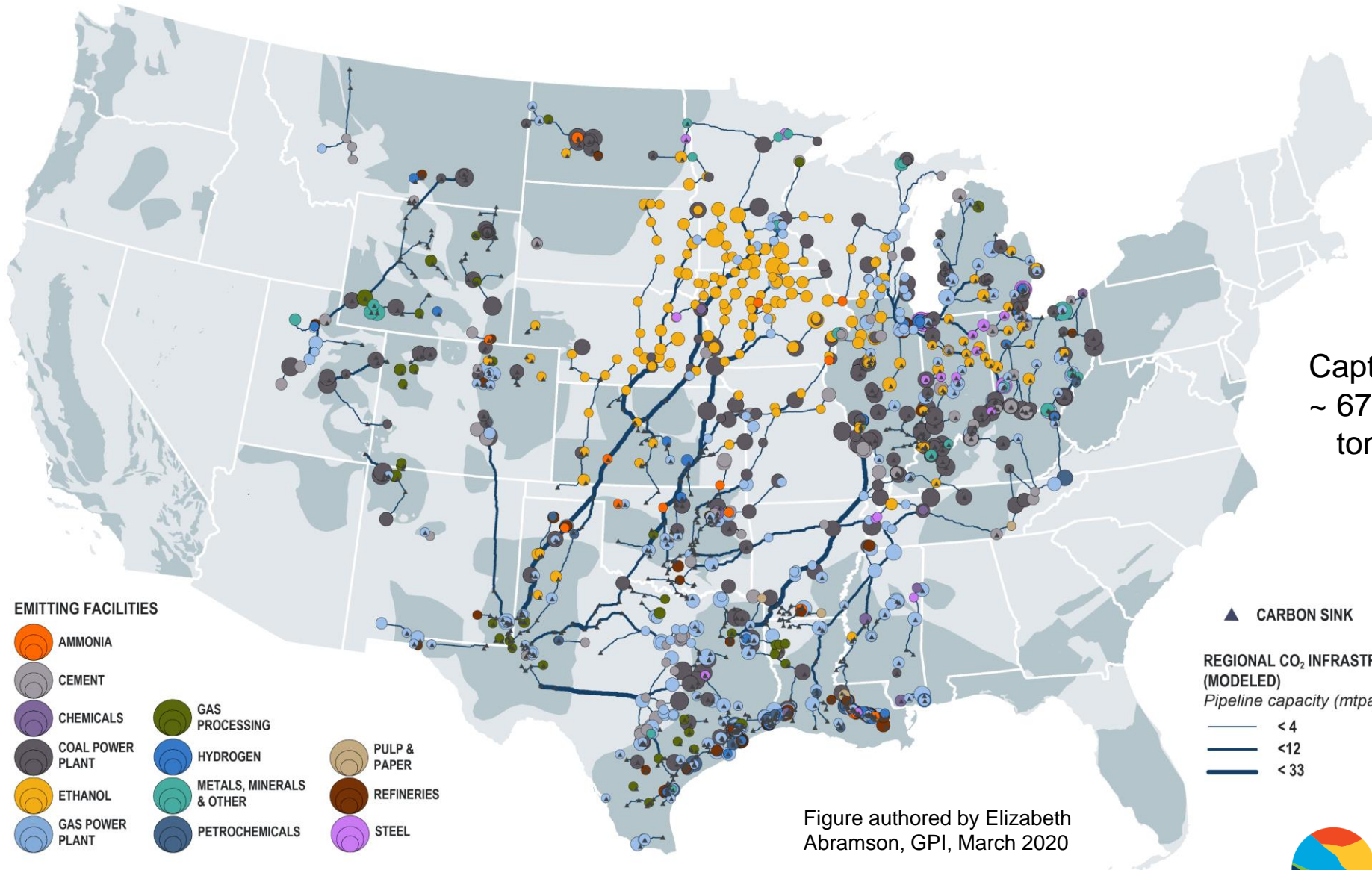
- EPA has only recently increased staff capacity to respond to Class VI permitting needs
- EPA reports more than 50 Class VI permitting inquiries
- Interested states may be able to act faster with primacy while following the UIC regulatory framework
- 8 states have convened around Class VI Primacy issues
- Bipartisan Scale Act (H.R. 1992, S. 799) would increase EPA funds for Class VI permitting and provide grants for state programs



- **North Dakota** and **Wyoming** have been granted *primacy* to regulate Class VI through state departments
- **Louisiana** has applied for Class VI Primacy, with **approval expected in 2022**.

Midcentury: Long-term Economy-Wide Deployment

Expanded storage in saline formations and petroleum basins



Capture and storage:
~ 670 million metric
tons per year

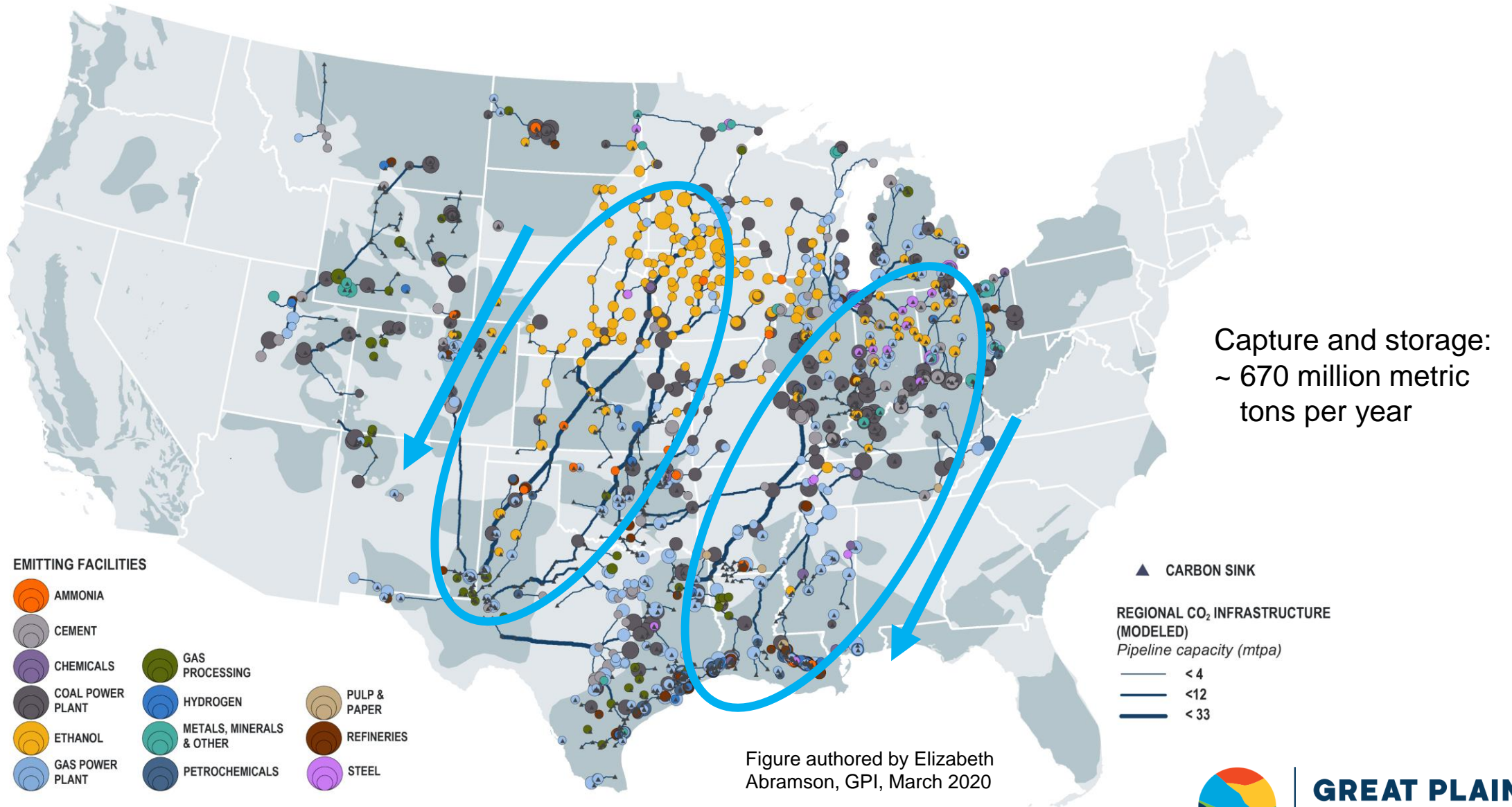
Figure authored by Elizabeth
Abramson, GPI, March 2020



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Midcentury: Long-term Economy-Wide Deployment

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Thank You

Dane McFarlane
Director of Research
Great Plains Institute
dmcfarlane@gpisd.net



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